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Warwick
Nash

pacific TUNA DEVELOPMENT FOUNDATION
P.O. Box 2359 Honolulu, Hawaii 96804

2. PROJECT SUMMARY

A. Project Title: Trochus Reseeding and Production of Giant Clams

B. Applicant Name: Pacific Tuna Development Foundation

C. Principal Investigator: G. A. Heslinga, F. E. Perron and Marine Resources Department, Palau

D. Primary Objective of Project: To restock the reef areas of Palau with juveniles of the giant tridacnid clam in addition to a continuation of the trochus reef reseeding program.

E. Summary of Work to be Performed: The principal investigators will survey natural stocks of giant clams, improve handling, develop further data on both natural and induced spawning, develop further data on larval mortality, release seed, monitor survival and prepare project reports. Determine the trochus production capacity of the MMDC hatchery, survey natural stocks, release juveniles, monitor survival and prepare project reports.

F. Direct Benefits and Beneficiaries of Project Results: The project will result in the production of 150,000 giant clam seed of which 30 percent will be selected for grow-out to commercial size. The 50,000 clams that reach market size will produce approximately 25 tons of adductor muscle worth more than $500,000 at dockside in Palau. Trochus that reach market size (approximately 300,000) will be worth approximately $100,000 in foreign exchange to Palau. All residents of Palau will benefit from the clam/trochus seeding program.

G. Principal Geographic Impact of Project: Regional

H. Project Duration: Clams - One Year of Three-Year Project
Trochus - One Year

I. Total Project Costs: $157,862

J. Project Costs to be Provided from Non-Federal Government Sources: $ 57,478 (36%)

K. Total Federal Funds Requested: $100,384 (64%)

L. Principal Use of Federal Funds:

Personnel Contracts	$ 56,000
Travel and Per Diem	5,000
Boat Charter	6,500
Rentals Equipment	6,050
Printing and Stationery	2,000
Expendable Supplies	3,000
PTDF Administrative/Management	21,834
	$100,384

3. PROJECT DESCRIPTION Trochus Reseeding

A. IDENTIFICATION OF THE PROBLEM(S)

Background:

The large marine snail Trochus niloticus is the object of a multi-million dollar mother-of-pearl industry in the tropical Indo-Pacific region. In Palau, trochus shell exports account for more foreign exchange than any other marine resource except tuna. The economic importance of the trochus industry in Palau is sufficient to justify a comprehensive management plan, but at present no such plan exists. It is evident from catch records and from population size structure analyses that major reef areas near Koror have been overexploited and are producing less than optimum yields. Palau's average annual trochus yields are now 50-70 percent lower than those reported in previous decades, despite an apparent increase in fishing effort.

Evidence of stock depletion in Palau, in conjunction with recent advances in trochus mariculture, prompted the Palau Marine Resources Division to seek PTDF assistance for a 36-month program of trochus hatchery development, stock assessment, reef reseeding and life history research.

B. PROJECT GOALS AND OBJECTIVES

The project is presently in its second year of operation and has as its primary objectives:

1. Commercial-scale hatchery production of trochus seed.

2. Determination of the cost-effectiveness of reseeding trochus reefs.

3. Survey of natural stocks and evaluation of the trochus marine sanctuary concept.

4. Research on key life history and population management parameters, including size-specific rates of growth, fertility, natural mortality, fishing mortality, total mortality and catch per unit effort.

5. Development and implementation of a model trochus management scheme based on data from activities 1-4 above.

Specific Goals:

1. Resource Assessment

Survey adult and juvenile stocks in each of 24 trochus sanctuary sites in Palau, and in adjacent free access areas, to evaluate the effectiveness of the sanctuary system as a management method. It is already clear that many sanctuary sites were chosen arbitrarily and are inappropriate trochus habitats. In addition, the high number of sanctuary sites makes effective surveillance by Marine Resources personnel impossible. Consideration will be given to relocating and consolidating certain sanctuary areas, based on survey results.

2. Hatchery Development

Increased production capacity of the existing trochus hatchery at the MMDC in Palau to a production level of 5 million 5 mm juveniles per year. Conduct basic research on trochus reproduction, development and population dynamics, and refine methods for maximizing growth and survival of larvae and juveniles in the hatchery.

3. Reseeding Program

Implement and evaluate a large-scale reef reseeding program. Release 5-10 million trochus juveniles in selected sites, following assessment of natural stocks. Determine juvenile mortality rates through cohort size frequency analysis. Determine potential recovery rate of seed after market size has been reached (less than two years). Define optimal seed size, based on production cost and potential recovery rate. Assess the economic feasibility of hatchery expansion and sale of trochus seed to other Micronesian districts.

C. APPROPRIATENESS AND NEED FOR GOVERNMENT FINANCIAL ASSISTANCE

Palau's present trochus conservation laws include sanctuary areas in each municipality, restriction of the collecting season to one month per year and a three-inch limit on the size of harvested specimens. These measures are helpful and have probably prevented a total collapse of the fishery. Nevertheless, it is clear that trochus stocks on Palauan reefs have been seriously reduced through intensive harvesting, and that the present annual yield is not a full realization of the economic potential of the resource.

A trochus management program based on systematic reseeding of depleted reef areas will result in greater annual production levels. This will have the positive effect of increasing employment and cash revenues to the fishermen and families involved in the harvest.

It is important to note that trochus fishing is a well established industry in Palau, with techniques and export infrastructure established decades ago. Palauans collect trochus with great enthusiasm, and the activity has considerable social and cultural significance here because it is consistent with a long tradition of reef gleaning and near-shore fishing. Participation in the harvest requires no great skill, risk or capital investment, and typically, whole families are involved. With the recent and increased interest in the development of offshore marine resources in Micronesia, the traditional and artisanal reef fisheries should not be permitted to suffer from mismanagement or lack of attention because of newly displaced priorities.

D. PARTICIPATION BY PERSONS OR GROUPS OTHER THAN THE APPLICANT

The trochus project will employ a fisheries specialist and a Palauan fisheries technician. The fisheries specialist will be trained in all phases for hatchery and field operations, and will assume responsibility for continuing the project following completion of the proposed grant period.

E. FEDERAL, STATE AND LOCAL GOVERNMENT ACTIVITIES

Palau's most recent Five Year Indicative Development Plan assigned marine resource utilization first priority as a means of increasing local and export earnings. Increased primary production of renewable local marine resources is widely recognized as the most desirable way to offset the present trade imbalance here.

Present laws relating to the number and location of trochus sanctuaries in Palau need revision. New legislation concerning these conservation measures will be recommended following the survey of natural stocks and consultation with chiefs in each municipality.

F. PROJECT OUTLINE

Activity Schedule	Months 1	6	12
Hatchery development, seed production and basic research	x	x	x
Survey of natural stocks	x	x	x
Release of seed	x		x
Monitoring of seed survival	x	x	x
Report preparation	x	x	x
Recommendations to Legislature			x

Explanation of Activities:

1. Hatchery Development, Seed Production and Basic Research.

This phase will be aimed at defining production capacity of the MMDC hatchery. Growth and survival of juvenile trochus are limited by water flow rate and surface area for algal grazing. Algal production is limited by sunlight, water flow rate, nutrient availability, and substrate area. Algal production per unit surface area will be maximized by suspending vertical substrate panels in outdoor flowing seawater raceways. Aspects involving spawning periodicity and larval development are well enough understood that obtaining large quantities of viable, fertilized eggs will not be a problem. There are no published data on clutch size or clutch frequency in individual Trochus niloticus, however, and these aspects of the life history will be investigated since they are of considerable value from a management perspective. Growth rates of trochus have been investigated by several authors, but no convincing data are available for Palauan populations. Therefore, a growth curve will be determined after a six-month mark and recapture study in a selected sanctuary.

2. Survey of Natural Stocks

Transect surveys will be made of 24 sanctuary sites and an equal number of adjacent free-access sites to determine densities of trochus adults and juveniles. Each of the surveys will require a minimum of three project personnel and a boat for one full day. The total number of days devoted to the survey will thus be approximately 50, and this phase will be conducted during the first 24 months of the project. An extended time frame is necessary for this phase because surveys can be conducted properly only during calm seas and spring low tides. For surveys near the district center of Koror, a 17-foot Boston Whaler with 55 hp. outboard engine will be rented from MRD. Surveys conducted on extreme northern and southern reefs will require the use of a larger boat, such as the 30-foot diesel Yamaha, also available for rental from Marine Resources in Palau.

3. Release of Seed

Beginning one year after initiation of the project, juveniles produced in the hatchery will be released in three selected areas where detailed surveys of natural stocks have already been conducted.

4. Monitoring of Seed Survival

Size frequency data from analysis of released cohorts and catch per unit effort data collected during monthly follow-up surveys will be used to determine growth and mortality rates of the released juveniles. This phase will be conducted during the second and third years of the project, and will require a Boston Whaler and approximately six days' work per month by the project leader and two assistants. The main objective will be to assess size-specific juvenile mortality rates, which in conjunction with hatchery production cost estimates, will permit determination of optimal seed size.

5. Report Preparation

Reports will be in preparation continuously during the project, and will include a series of technical papers submitted to scientific journals, quarterly reports submitted to PTDF and popular articles published through the local media.

6. Recommendations to the Legislature

Results of the Survey of Natural Stocks will serve as a data base for a critical evaluation of the trochus sanctuary system. Since many sanctuaries are located in inappropriate habitats, legislation will be recommended to relocate and consolidate the sanctuaries in more favorable areas. In addition, legislation will be recommended that will delay initiation of the trochus harvesting system until after the new moon period when adults are known to spawn.

G. PROJECT MANAGEMENT

The project will be coordinated through the Palau Marine Resources Division, under the direction of the District Fisheries Officer and the PTDF program manager. The Co-Principal Investigators on the project will be Mr. Gerald Heslinga and Dr. Frank Perron. Each will assume a half-time appointment with PTDF. Mr. Heslinga is the current Principal Investigator on the trochus project. Dr. Perron is presently the Director of the MMDC in Palau and has already participated in and assisted with several aspects of the trochus project, including stock surveys, hatchery production and data analysis.

In addition to the project leaders, the trochus project will require one fisheries specialist and one fisheries technician. The fisheries technician will be a Palauan with a high school diploma and experience in fisheries, small boat operation and coastal navigation. The fisheries specialist will be a Palauan biologist with experience in marine resources or with a college science degree. The project leader will train the fisheries specialist in all necessary aspects of hatchery management, field work and report preparation, so that this individual may assume leadership of the project following the proposed grant period.

H. MONITORING OF PROJECT PERFORMANCE

The project will be monitored by the PTDF project manager and the project coordinators at Palau. Quarterly reports will be prepared and forwarded to the PTDF program manager. If for any reason the project must be terminated, no further payments will be made by PTDF to the participants and unexpended monies will revert to the PTDF gneeral fund.

I. EVALUATION OF PROJECT RESULTS

The project leader will submit quarterly reports and technical reports to the PTDF program manager. Success of the project will be determined by:

1. Realization of hatchery production goals.

2. Increased annual trochus yields based on recovery of seeded juveniles.

3. Adoption by the Legislature of new, more effective trochus sanctuary regulations based on evidence from field studies.

4. Publication of project results.

5. Increased public awareness of the need for trochus reseeding and conservation.

J. PROJECT BENEFITS

The project will result in the employment and training of two Palauan Marine Resources personnel, one of whom will assume responsibility for leading the project at the end of the grant period.

As a result of local legislation and publication in local media describing the project, public awareness of reasons for reef reseeding and conservation will be improved.

The project will produce basic scientific information which will be of immediate value to Marine Resources personnel in Palau and in other trochus-producing districts in Micronesia. An assessment will be made of the cost effectiveness of reef reseeding as a means of increasing trochus yields in Palau. The present trochus sanctuary system in Palau will be critically evaluated and modified through the legislation. These activities will result in a model trochus management strategy that may be directly applicable in other Micronesian districts.

The goal of hatchery production will be about 5 million, 5 mm trochus seed per year, or 15 million seed produced during the three-year project. If only 2 percent (300,000) of these seed survive to market size after release, they will be worth approximately $100,000 in foreign exchange to Palau. If 5 percent of these seed are recovered, their value to Palau will be approximately $250,000. Their potential value is actually higher since these individuals will spawn several times before reaching legal harvestable size.

Since the MMDC hatchery has already produced one-half million trochus juveniles during a three-month period in 1979, the above hatchery production goals are realistic with present technology and facilities.

K. DISSEMINATION OF PROJECT RESULTS

The research and activities described in Section F will result in the following outputs in terms of technical reports:

1. Final project report for the PTDF program manager.

2. "Growth of *Trochus niloticus* in the laboratory." Manuscript in press.

3. "Survey of *Trochus niloticus* stocks on the reefs of Palau." Manuscript to be submitted 14 months after project initiated.

4. "Induction of metamorphosis in *Trochus niloticus* larvae with gamma-amino butyric acid: Application in a large-scale mariculture system." Manuscript in preparation.

5. "Growth and survival of hatchery-reared *Trochus niloticus* juveniles in nature." To be submitted during second year of project.

6. "Clutch size and clutch frequency in *Trochus niloticus*. Submitted after six months.

7. "Growth, maturity and longevity of *Trochus niloticus* in Palau." Submitted during second year of project.

8. "The status of the trochus industry in the Pacific Islands." Second year.

9. "Hatchery manual for *Trochus niloticus*." Second year.

These reports will be forwarded to PTDF program manager upon completion, and copies will be deposited in the libraries of the MMDC, the Palau Conservation Office and the Division of Marine Resources. Reports No. 2-7 will be published in appropriate scientific journals, such as *Aquaculture*, *Marine Biology*, *Bulletin of Marine Science*, *Marine Fisheries Review*, *Micronesia*, *Oecologia*, *Pacific Science* and *Marine Ecology*. Report No. 8 will be submitted to the South Pacific Commission for publication as an occasional paper.

Popular articles describing the trochus reseeding project will be submitted to *Pacific Daily News* and *Pacific Islands Magazine*, which are the two most widely read news publications in Palau.

PROJECT COSTS

	PTDF	State Cash/ In-Kind	U.S. Industry/ Hawaii In-Kind	Total
Personnel Contracts and Per Diem				
Principal Investigators - 2 - One year at $2,800	$56,000			
Travel and Per Diem	3,000			$59,000
Investigators Housing		$8,760		$ 8,760
Vessel Charter		6,500		$ 6,500
Rentals Equipment				
Scuba and Diving	$ 2,000			
Computer Time	1,750			
Pickup Truck	2,300			$ 6,050
Other				
Printing and Publications	$ 1,000			
Expendable Supplies	2,116			$ 3,116
Technician Salary - 4 @ $6,000		$24,000		
Clerical		4,000		
Rental Lab Space		4,380		
Rental Tank Space and Bottom Lease		5,000		$37,380
PTDF Administrative/Management	$21,834			$21,834
U.S. Industry/Hawaii In-Kind			$11,338	$ 11,338
TOTAL	$90,000	$52,640	$11,338	$147,478

COST SHARING FOR THE PROJECT

Federal Funds	
Project Costs	$68,166
PTDF Administrative/Management	21,834
	$ 90,000
State Cash/In-Kind	$52,640
U.S. Industry/Hawaii In-Kind	$ 11,338
	$153,978

4. SUPPORTING DOCUMENTATION

A. Two manuscripts describing the MMDC's recent advances in giant clam mariculture are appended. These provide a review of the scientific literature on clams, explain methods used in clam culture, and offer an assessment of the potential for commercial culture of giant clams.

Heslinga, G.A., Perron, F.E. and Orak, O. Mass Culture of Giant Clam in Palau. Developments in Aquaculture and Fisheries Science, in press.

Munro, J.L. and Heslinga, G. Prospects for the Commercial Cultivation of Giant Clams (Bibalvia: Tridacnidae). Proceedings of the Gulf and Caribbean Fisheries Institute, 35, in press.

B. Correspondence from Palau National Resources Minister, Koichi Wong and from Surangel Whipps, Executive Officer of Ngatpanc State, are included to document local interest and support of the proposed giant clam project.

C. Three photographs are appended to illustrate the giant clam rearing process and the specimens already produced at the MMDC in Palau.

D. References

Heslinga, G.A. and Hillmann, A. 1981. Hatchery Culture of the Commercial Top Snail *Trochus niloticus* in Palau, Caroline Islands. Aquaculture 22: 35-42.

Heslinga, G.A. 1981. Larval Development, Settlement and Metamorphosis of the Coral Reef Gastropod *Trochus niloticus*. Malacologia 20: 349-357.

Heslinga G.A. 1982* Growth and Maturity of *Trochus niloticus* in the laboratory. Proceedings Fourth International Coral Reef Symposium, Manila, Philippines. In press.

Heslinga, G.A. 1981. Report on Palau's Trochus Hatchery. South Pacific Commission Fisheries Newsletter 20: 4-8.

Heslinga, G.A. submitted. Diel and Lunar Spawning Periodicity in the tropical gastropod *Trochus niloticus*.

Heslinga, G.A. Submitted.* A Permanent Tag for Large Marine Gastropods.

Heslinga, G.A. Submitted.* Patterns of Larval Development in Tropical Trochid Gastropods.

Heslinga, G.A. and Orak, O., Manuscript. Hatchery Manual for the Topshell *Trochus niloticus*.

*Reports produced with PTDF support.

PACIFIC TUNA DEVELOPMENT FOUNDATION

APPLICATION FOR FY 83

Summary

	Project Costs	PTDF Admin.	PTDF Management	Total (%) Federal Funds	Local State Cash/In-Kind	U.S. Industry/Hawaii Cash/In-Kind	Total Non-Federal (%)	Total
Fishing on Aggregation Devices, Exploration, Projection Fishing & Training (Am. Samoa)	$ 48,360	$ 9,740	$ 8,644	$ 66,744 (69%)	$ 21,900	$ 7,936	$ 29,836 (31%)	$ 96,580
Fish Handling, Processing and Market Training (American Samoa)	35,000	9,740	6,047	50,787 (74%)	12,500	5,669	18,169 (26%)	68,956
Topminnow Test Fishing (Hawaii)	5,000	1,000	1,000	7,000 (50%)	6,000	1,000	7,000 (50%)	14,000
Studies on the Detection, Causes and Control of "Burnt Tuna" in Night Handline Tuna Fishing Industry (Hawaii)	37,000	9,740	6,047	52,787 (60%)	30,000	5,669	35,669 (40%)	88,456
Night Handline Tuna Fishery Study (Hawaii)	30,000	9,740	4,838	44,578 (72%)	12,600	4,535	17,135 (28%)	61,713
Efficient Fishing Vessel Design and Feasibility (Hawaii)	5,000	1,000	1,000	7,000 (56%)	4,500	973	5,473 (44%)	12,473
Night Handlining for Tuna "Ika Shibi" (Northern Marianas)	46,200	9,740	7,256	63,196 (81%)	8,500	6,802	15,302 (19%)	78,498
Trochus Reseeding & Production of Giant Clams (Palau)	78,550	9,740	12,094	100,384 (64%)	46,140	11,338	57,478 (36%)	157,862
Anchored Fish Aggregation Devices (Yap)	51,288	9,740	8,644	69,672 (60%)	39,192	7,936	47,128 (40%)	116,800
Development of Resource Management Programs (Ponape)	45,054	9,740	7,256	62,050 (66%)	25,317	6,802	32,119 (34%)	94,169
Truk Shipyard Study (Truk)	23,000	9,740	3,697	36,437 (81%)	5,000	3,401	8,401 (19%)	44,838
Operational Protocal Moen Freezer Plant (Truk)	26,450	9,740	4,838	41,028 (81%)	5,000	4,535	9,535 (19%)	50,563
Guam Coop Development and Marketing Assistance (Guam)	78,200	9,740	13,304	101,244 (70%)	31,000	12,471	43,471 (30%)	144,715
Western Pacific Transshipping Study (U.S. Tuna Industry)	23,000	9,740	3,628	36,368 (79%)	6,000	3,697	9,697 (21%)	46,056
Island States Vessel and Infrastructure Inventory Repair, Maintenance and Training	200,000	9,750	32,655	242,405 (76%)	48,000	30,611	78,611 (24%)	321,016
TOTAL	$732,102	$128,630	$120,948	$981,680 (70%)	$301,649	$113,375	$415,024 (30%)	$1,396,704

LIVING MARINE RESOURCES, INC.
PTDF PROGRAM MANAGER

DISTRIBUTION OF MANAGEMENT BUDGET BY PROJECT ELEMENTS

Fishing on Aggregation Devices: Exploration Projection Fishing and Training - American Samoa	$ 8,644
Fish Handling, Processing and Market Training - American Samoa	6,047
Topminnow Test Fishing - Hawaii	1,000
Studies on the Detection, Causes and Control of "Burnt Tuna" in Night Handlining Tuna Fishing Industry - Hawaii	6,047
Night Handline Tuna Fishery Study - Hawaii	4,838
Efficient Fishing Vessel Design and Feasibility - Hawaii	1,000
Night Handlining for Tuna (Ika-shibi) - Northern Marianas	7,256
Trochus Reseeding and Production of Giant Clams - Palau	12,094
Anchored Fish Aggregation Devices - Yap	8,644
Development of Resources Management Programs - Ponape	7,256
Truk Shipyard Study - Truk	3,697
Operational Protocol Moen Freezer Plant - Truk	4,838
Guam Co-op Development and Marketing Assistance - Guam	13,304
Western Pacific Transshipping Survey	3,628
Island States Vessels and Infrastructure Inventory, Repair, Maintenance and Training	32,655
	$120,948

PACIFIC TUNA DEVELOPMENT FOUNDATION

HONOLULU ADMINISTRATIVE OFFICE

DISTRIBUTION OF ADMINISTRATIVE BUDGET BY PROJECT ELEMENTS

Fishing on Aggregation Devices, Exploration, Projection Fishing & Draining (American Samoa)	$ 9,740
Fish Handling, Processing and Market Training (American Samoa)	9,740
Topminnow Test Fishing (Hawaii)	1,000
Studies on the Detection, Causes and Control of "Burnt Tuna" in Night Handline Tuna Fishing Industry (Hawaii)	9,740
Night Handline Tuna Fishery Study (Hawaii)	9,740
Efficient Fishing Vessel Design and Feasibility (Hawaii)	1,000
Night Handlining for Tuna "Ika Shibi" (Northern Marianas)	9,740
Trochus Reseeding & Production of Giant Clams (Palau)	9,740
Anchored Fish Aggregation Devices (Yap)	9,740
Development of Resource Management Programs (Ponape)	9,740
Truk Shipyard Study (Truk)	9,740
Operational Protocal Moen Freezer Plant (Truk)	9,740
Guam Coop Development and Marketing Assistance (Guam)	9,740
Western Pacific Transshipping Study (U.S. Tuna Industry)	9,740
Island States Vessel and Infrastructure Inventory Repair, Maintenance and Training	9,750
TOTAL	$128,630

UNITED STATES TUNA INDUSTRY AND STATE OF HAWAII

IN-KIND CONTRIBUTION COMMITMENT TO PTDF PROGRAM ELEMENTS

Fishing on Aggregation Devices: Exploration Projection Fishing and Training - American Samoa	$ 7,936
Fish Handling, Processing and Market Training - American Samoa	5,669
Topminnow Test Fishing - Hawaii	1,000
Studies on the Detection, Causes and Control of "Burnt Tuna" in Night Handlining Tuna Fishing Industry - Hawaii	5,669
Night Handline Tuna Fishery Study - Hawaii	4,535
Efficient Fishing Vessel Design and Feasibility - Hawaii	973
Night Handlining for Tuna (Ika-shibi) - Northern Marianas	6,802
Trochus Reseeding and Production of Giant Clams - Palau	11,338
Anchored Fish Aggregation Devices - Yap	7,936
Development of Resources Management Programs - Ponape	6,802
Truk Shipyard Study - Truk	3,401
Operational Protocol Moen Freezer Plant - Truk	4,535
Guam Co-op Development and Marketing Assistance - Guam	12,471
Western Pacific Transshipping Survey	3,697
Island States Vessels and Infrastructure Inventory, Repair, Maintenance and Training	30,611
	$113,375